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ADDRESS

Delivered by the President, Mr. H. F. Newall, on presenting the Gold Medal of the Society to Sir David Gill, K.C.B., F.R.S.

For the second time in the history of our Society, your President is called upon to present the Gold Medal to Sir David Gill. By their award in 1882 the Council desired to recognise the value of his work in determining the solar parallax from observations of Mars in Ascension; and now, after a quarter of a century, they have awarded the Gold Medal to him in recognition of his contributions to the Astronomy of the Southern Hemisphere, and his other astronomical work.

In fulfilling the task which it is my privilege to attempt this afternoon, I would begin by assuring Sir David Gill of the pleasure which it is to us to have him at home again among us with his vigour unabated. We look forward to the prospect of our having his help in our counsels for many years to come.

The terms of the Council's award are wide. They cover the large range of work which Sir David Gill has accomplished during the twenty-eight years of strenuous activity which he has spent in his capacity as His Majesty's Astronomer at the Observatory of the Cape of Good Hope. It would be a difficult matter to decide whether Sir David Gill has contributed to the advance of astronomy in those years more by his own observational work or by the active performance of his administrative duties. Fortunately it is not part of my task to try to disentangle these two aspects of his work.

Broadly speaking, by his personal labours we have such achievements as his two sets of heliometer determinations of the parallaxes of certain southern stars, and his three determinations of the solar parallax. By his administrative activity the Cape Observatory has been equipped entirely anew with modern first-class instruments; a vast store of astronomical material has been rendered available for the use of astronomers; not only are the last remaining observations of his predecessors reduced and published, but also the observational materials collected in Sir David Gill's régime are reduced and published up to date.

And, as if these duties were not enough to occupy him, Sir David Gill devoted himself to promoting a unified scheme of geodetic survey of South Africa. In his latest utterance about this work in his Presidential Address to the British Association, Sir David Gill speaks of the great African arc on the 30th meridian.

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He says of it that it is the dream of his life to see it completed. When I heard these words at Leicester, it seemed to me that they represented Gill's general frame of mind. Whenever he set his hand to any bit of work, it became the dream of his life to see that particular bit of work completed in the most comprehensive way that he could attain. This frame of mind does not always meet with sympathy; it is liable at times to rouse keen opposition. But Gill has seldom failed to infect others with something of his own enthusiasm.

In doing honour to Gill's work, we shall not in the least detract from it if we pay the sincerest tribute to the co-operation which he has been able to elicit from many workers in many lands. We must not forget the devotion of his staff at the Cape Observatory. We must remember the liberal support he has received from the Lords Commissioners of the Admiralty, both for increased instrumental equipment and for increased staff to deal with the expanded scope of the work. We must pay a tribute to the memory of our late Fellow, Frank McClean, whose generous munificence provided the astrophysical department at the observatory. We shall not forget the services rendered by Professor Kapteyn in the *Cape Photographic Durchmusterung*, nor those of Dr. Elkin and Dr. Auwers in their allotted tasks in the solar parallax work, nor yet those of Sir W. Morris and many other officers in the geodetic work.

Paying tributes in this wise is only a way of recognising Gill's power of inspiring others to take part in advancing the subject which it is the object of our Society to encourage.

History and Traditions at the Cape.—It has been of great interest, in preparing to write this address and in trying to attune myself to the nature of the surroundings in which Sir David Gill has worked, to trace back through the prefaces of early volumes of observations and through the annual reports something of the history and traditions of the Royal Observatory at the Cape of Good Hope. What an enthralling history it would make for us astronomers if it were written by someone who had the power of picturesque presentation.

We should see Fallows, the first astronomer at the Cape (1821–1831), awaiting for three and a half years the delayed plans of his observatory, and filling up his spare moments by opening a school and teaching the children of neighbouring farmers—his fee for each lesson a load of earth, which helped to make the foundation of a garden on the rocky hill chosen for the site of the observatory. We should hear of his applying in vain for permission to measure an arc of meridian.

We should read how he struggled on, making the best of his portable instruments, till the observatory buildings were finished and the permanent instruments were installed—seven years after his arrival at the Cape. Then, after a couple of years of vigorous observations, his able assistant Captain Ronald fell sick, and Fallows would have been left alone at the work but for the

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assistance which his wife learned to render by taking the circle readings whilst he was engaged with the transit. It was generous official help that he needed, but before it arrived fever had attacked him and he died in the forty-third year of his age. It is a sad story of a brave man struggling to implant new work in a distant land, and it should make us remember the debt of help that we at home owe to those who are working at a distance from headquarters.

Next we should read of Henderson, who went to the Cape in 1832 and worked there assiduously for thirteen months before he uttered that wail of despair about the situation of the observatory on Snake Hill. He describes it as "on the verge of an extensive sandy desert, exposed to the utmost violence of the gales which frequently blow, without the least protection from trees or other objects to shelter from the wind or sun, some miles from markets, shops, or the habitation of persons with whom those belonging to the observatory can associate." It was in such surroundings that Henderson, with the assistance of Lieut. Meadows, achieved those observations which have made his name famous. He took most of his material back to Edinburgh, and year by year he found time, in the midst of his duties as Astronomer Royal for Scotland, to reduce it all. Our Society had the honour of publishing in its early memoirs fifteen contributions from him dealing with his Cape observations, including his memorable determination of the parallax of α Centauri.

Next we should find Maclear (1834–1870) boldly coming out, at heart a true colonist, making roads, harnessing the wind to draw a water-supply, carting earth, planting trees and rows of pine and wattle to form shelter. By exchange and sale and purchase of land he consolidated the observatory property, and succeeded in getting convenient communication with the main road to Cape Town. Of his scientific labours, it is enough to recall his measurement of an arc of meridian, his multitudinous meridian observations, partly reduced under his own régime, and revised and published by his successors Stone and Gill in the form of four Cape Catalogues for the equinoxes 1840, 1850, 1860, and 1865, which deal with a total of 10,766 stars. In his régime, too, two equatorials were added to the equipment, and with these his observations of comets, nebulæ, double stars, and occultations were made. A new transit-circle was installed.

So, at the end of Sir Thomas Maclear's directorate in 1870, when he withdrew from the observatory to live for the remaining nine years of his life at Mowbray, within a mile of the scene of his former labours, we should see Stone (1870–79) coming out to the Cape to find an established home and an observatory containing a transit-circle the facsimile of that at Greenwich. Stone was at once engrossed in completing two great objects, (i) the preparation of Maclear's meridian observations for press, and (ii) the re-observation of the stars which had been observed by Lacaille more than a century before. He completed the latter undertaking by the formation of the Cape Catalogue for 1880, containing the places of 12,441 southern stars to the seventh magnitude. During his directorate

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he passed through the press two Cape Catalogues for 1840 and 1860, based on Maclear's observations made during thirteen years.

This is in briefest outline the history of the observatory at the Cape of Good Hope up to the year 1879, when Stone returned to England to take up his duties as Radcliffe Observer at Oxford. We have seen the traditions forming—

(1) The stellar parallax tradition, implanted by Henderson in his studies of α Centauri, and fostered by Maclear.

(2) The geodesy tradition, implanted first in African soil by the Abbé Lacaille, in vain desired by Fallows, and firmly rooted by Maclear.

(3) The tradition of the Cape Catalogue, implanted by Fallows in his first catalogue of 273 stars, fostered by Airy in his reduction of Fallows' last observations, and firmly fixed by Maclear and Stone,—in fact, the traditions of general astronomy.

Into all this goodly heritage of history and tradition Sir David Gill entered in 1879; and looking back upon the records of his directorate, we find he has fostered and extended each one of the traditions he found at the Cape, and has implanted as many more as he found.

Thus by the accumulated labours of its Directors the Cape Observatory has grown to be an observatory of the first rank, of which the nation may justly be proud.

Stellar parallax.—First and foremost among the new traditions we must put the heliometer tradition. Gill's masterly use of this instrument has given us those refined determinations of stellar parallax and of solar parallax, those observations of planets and satellites, and triangulations of stars, that are so honourably connected with his name.

Let me first refer to the determinations of stellar parallaxes, one of his most notable contributions to the astronomy of the southern hemisphere. He has made two sets of determinations; the first were made with a 4-inch heliometer. This instrument was an old friend, for he had used it in Lord Crawford's expedition to Mauritius in 1874, and had also made his observations of Mars with it at Ascension in 1877. Gill knew he could use it effectively in stellar parallax determinations, and he had acquired it from Lord Crawford for this purpose. Just before he left Europe to take up his duties at the Cape, Gill was fortunate enough to find a young and able astronomer eager to join him in the parallax work. He invited him to come to the Cape as soon as he should have finished his studies at Strassburg. Thus it was that Dr. Elkin went out to the Cape in 1881. For more than two years, a guest in Gill's house, he took his share in Gill's labours, and made it a labour of love.

Their programme of parallax observations was an interesting one. First on the list of chosen stars was, of course, α Centauri, Henderson's star, which still retains its place as the nearest star in the whole sky. Altogether nine of the most interesting stars in the southern heavens were included on the observing list, four

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stars, including *a* Centauri, being chosen for historical associations or for conspicuous brightness, and five others for large proper motion. These stars were judiciously divided between the two observers, so that each had six stars on his list. The comparison stars were chosen with great care, and in the case of the three stars common to the two lists each observer had his special comparison stars, so that we must regard the determinations as entirely independent. Each observer discussed his own observations, and the results were combined in the final account of the research published in the *Memoirs* of our Society, vol. xlviii. (1884).

The results were valuable, both in their bearing on the exact solution of the problem undertaken and by the effects produced by their attainment, for immediately after the completion of the work Sir David Gill represented to the Admiralty that continued research on stellar parallax and a new determination of the solar parallax by observations of minor planets were much to be desired, if only they could be carried out with a larger instrument provided with certain structural improvements which experience with the small heliometer had suggested. The Lords Commissioners promptly sanctioned the addition of a 7-inch heliometer to the equipment of the Cape Observatory.

Regular observing was begun with the new heliometer in January 1888, and in the next four years an astonishing programme of observations was successfully completed. It included—

(1) The complete determination of the constants and errors of the heliometer (scale value, errors of the micrometer screw and of the scale divisions, etc., involving nine months' labour).

(2) Observations for parallax of twenty-two stars.

(3) Observations of the three minor planets, Iris, Victoria, and Sappho, for the determination of solar parallax.

(4) Observations of Jupiter's satellites.

Gill's expectations of the new heliometer were fully realised; he satisfied himself that one observation made with it was of the same weight as three observations with the old instrument, and that one set of observations could be made in half the time that had been previously required.

The tables which summarise (in vol. vii. of the *Annals of the Cape Observatory*) the results for stellar parallax contain details relating to 12 *bright* stars and 10 stars of *large proper motion*; and among the 32 distinct determinations the name of our Medallist is attached to 18, Elkin's to 7, Finlay's to 3, and de Sitter's to 4. In several instances, by way of test, the parallax of the same star was investigated with both instruments, with substantially the same results. Gill completes his exposition of the observations by a discussion of the conclusions to be drawn from the results obtained. So far as so small a number of parallaxes as 22 can be utilised for such a generalisation, the Cape results seem to support the view which has gradually formed in the last twenty years, namely, that large proper motion is a safer criterion of proximity of a star to our system than brightness. We have learnt from the work of

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Stumpe, Kapteyn, and Newcomb and others to realise how much emphasis is to be laid on the probability that stars differ enormously in actual luminosity.

The point is beautifully illustrated by the tables which Gill has drawn up. It must be remembered, as he points out, that the derived parallaxes are differential or apparent, not absolute; for we are not at liberty to assume that the comparison stars are infinitely remote. The only legitimate procedure is to deal with limiting values, which can be obtained by adopting different hypotheses as to the absolute parallax of the comparison stars. Gill accordingly gives tables exhibiting the variation of the total light radiated by each of his parallax stars (in terms of the Sun's light), with different hypothetical parallaxes of the comparison stars, ranging from 0″·00 to 0″·05. It is thus made clear that the southern stars whose apparent parallaxes have been determined would differ in brightness by about 12–15 magnitudes if they were all removed to the same distance from the Sun.

The further tables which Gill gives to convert the observed proper motions of his parallax stars into absolute velocities in miles per second afford strong confirmation that the deductions about actual luminosity are legitimate. For the velocities deduced are nearly all within the limits which spectroscopic determinations have led us to expect among stars.

The beautiful photographic reproductions, given in the volume of results, of the spectra of α_2 Centauri and the Sun show what may be expected of the astrophysical department which Sir David Gill has laboured to develope at the Cape. I will not attempt to refer in detail to this spectroscopic work; for though the papers published by the Cape Observatory hitherto have dealt with important points, we are able to gather from references in the annual reports that the main forces are concentrated on yet another determination of the solar parallax by the spectroscopic method. We can well imagine the interest with which Sir David Gill is looking forward to the results of the work.

Cape Catalogues.—Before passing on to refer to Gill's work on solar parallax, I would advert to another of his large contributions to the astronomy of the southern hemisphere, namely, his faithful fostering of the Cape Catalogue tradition. Meridian work must necessarily form an important part of the work of a large national observatory. At the Cape much of the energy of the staff has always been devoted to this branch, and the result is a series of catalogues of star places which have a special value.

When Gill took up his duties at the Cape he found that, in spite of the indefatigable zeal of Mr. Stone, there were two periods (1849–52 and 1861–70) of valuable observations of Sir Thomas Maclear which still remained to be reduced and published. Stone had already begun the reduction of the observations of the first period, and Gill made it one of his first duties to complete and revise the reduction, and in 1884 the Cape Catalogue of 4810 stars for 1850 was published. The last remaining period (1861–70) of

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Maclear's observations was dealt with by degrees, and in 1900 the Cape Catalogue of 1905 stars for 1865·0 was published. We can well understand with what satisfaction the completion of this work was hailed. The preface contains the following remark:—"The publication of this catalogue marks an epoch in the history of the observatory. For the first time in that history the Director can feel that the accumulated labours of his predecessors are available for the use of astronomers, and that the work being done under his own direction is in a healthy and forward state of reduction and publication."

The first catalogue for which Sir David Gill is solely responsible is a catalogue of 1713 stars for 1885·0 published in 1894; the next is a catalogue of 3007 stars for 1890·0 published in 1898. In 1906 two more catalogues were published, an achievement of which the meridian circle department might well be proud. One is a catalogue of 8560 astrographic standard stars for the equinox 1900, to serve for the Cape section of the Astrographic Catalogue. The other is a catalogue of 4464 stars for the equinox 1900, based on observations made between 1900 and 1904, and containing, *inter alia*, the results of Cape observations of 2798 zodiacal stars which were entered on the list circulated by Sir David Gill, and adopted at the Paris Conference in 1896 as a list of stars suitable for reduction of heliometer observations of planets, etc. In this connection I may refer to another large undertaking. Since 1897 all the oppositions of major planets have been observed with the heliometer at the Cape.

The transit-circle, which has been in use since 1856, was carefully renovated in 1885. The instrument is similar to that at Greenwich. I wish I could have included in these remarks reference to a fifth catalogue, which will deal with other observations, already on the way to completion at the time of Sir David Gill's leaving the Cape. We shall look forward to it with great interest, for it will contain the results of comparison of the old and the new transit-circles at the Cape.

Gill has laboured to embody in the new transit-circle, which was erected in 1901, many new features which were designed with the object of making it possible to detect or eliminate all ascertainable sources of error in observations of fundamental stars.

In connection with his efforts to probe into these refinements of observational work, I would recall to your memory his careful discussion of the meridian observations made for the reduction of his heliometer measures of Mars at Ascension. He then definitely discovered that curious variation of personal equation known as the magnitude equation. In virtue of this troublesome peculiarity, a transit observer watching the passage of bright and faint stars over a wire records the transit a little later for a faint star than for a bright star. The result is that the right ascension interval between a faint and a bright star is a little too large when the bright star leads, and is a little too small when the faint star leads. The effect is a small one, but is very troublesome in cases where

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great refinement is needed in star places; the trouble is all the greater because the magnitude of the effect varies appreciably among different observers.

Sir David Gill has introduced in the Cape Catalogues, *e.g.* that of Astrographic Standard Stars for 1900·0, corrections for magnitude equation applied separately for each observer. The latest contribution to the experimental study of the effect is one made at the Cape Observatory, and communicated to our Society last April. The authors, Sir David Gill and Mr. Hough, discuss therein the results of a comparison of right ascension differences measured in three independent ways—(1) with the old transit method, (2) with the new transit and travelling wire, and (3) with the heliometer. The results show that within the range of magnitudes (3½–8½) of the stars observed, the magnitude equation is barely appreciable with the new transit-circle fitted with the travelling wire.

Cape Photographic Durchmusterung.—I turn now to remind you of another great undertaking which we owe to the initiative of our Medallist, viz. the *Cape Photographic Durchmusterung.* There is scarcely need for me to refer to it in any detail, for the history of it must be vivid in your memory from the account which Dr. Glaisher gave of it in presenting the Medal to Professor Kapteyn in 1902. The *Cape Photographic Durchmusterung* arose out of the success which Gill achieved in photographing the comet of 1882; he saw the beauty of the many star-images that appeared on the photograph down to the 9th magnitude, and soon afterwards he proved that large photographic cameras could be effectively employed for constructing photographic star maps. He proceeded forthwith to secure the systematic photographical survey of the southern skies, and gave us what may be briefly described as an extension of the *Bonn Durchmusterung* to the South Pole. Kapteyn's measurement and reduction of the plates remains a splendid instance of scientific devotion. It gives us, under the title of the *Cape Photographic Durchmusterung*, in three large volumes of the *Annals of the Cape Observatory*, the approximate places and magnitudes of 454,875 stars,—in fact, a catalogue of all the stars down to the 9¼ magnitude, and most of those to the 10th magnitude between declination 19° S. and the South Pole. This survey has not only served admirably for a study of stellar distribution in the sky, but by the industrious co-operation of Professor Kapteyn at Groningen and Mr. Innes at the Cape it has also led to the discovery and study of many variable stars, a fact which is attested by observations recorded in the fourth volume, containing the details of the work of revision of the *C.P.D.*

Astrographic Chart and Catalogue.—The present year is the twenty-first anniversary of the inception of the *Astrographic Chart* and *Catalogue.* In the original initiation of this scheme of international co-operation Sir David Gill took a deep interest and also a large share. Admiral Mouchez, by whose tact and energy the initial steps of promoting the harmonious co-operation of

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eighteen observatories in different parts of the world were successfully conducted, has testified to the fact that Gill's success in photographing the comet of 1882 opened the way to the Chart, for it proved that we had reached the point of being able to construct the chart of the heavens by photography. The skill of the Brothers Henry, not only in developing the construction of object-glasses large enough and suitably achromatised for stellar photography, but also in producing their superb photographic star charts, was probably the decisive factor in the acceptance of the plan agreed upon in 1887.

The Cape Observatory at once became one of the eighteen contributories to the scheme; the zone −40° to −52° was allotted as its portion of the sky. The astrographic telescope made by Sir H. Grubb arrived at the Cape in 1890, and after some alterations and experimental researches the work was begun in 1893 and has gone steadily forward. By the end of 1897 the required 1512 catalogue plates had all been obtained and nearly half of the chart plates. In the following year it was decided to re-photograph the whole zone for the catalogue, in order to bring the epoch at which the plates were taken nearer to that at which the comparison stars were observed on the meridian. This plan also rendered it possible to determine with sufficient accuracy the proper motions of the reference stars in the numerous instances where no meridian observations existed previous to the epoch of the latest Cape observations.

In 1900 Sir David Gill undertook, in addition to the zone, to photograph the area within 2° of the South Pole, originally allotted to the Melbourne Observatory; it will thereby be possible to combine the photographic work with the Cape heliometer triangulation of this region, and with the results of the Cape discussions of all the meridian observations of southern close circumpolar stars.

The measurement of the plates was well started in 1898, with the aid of a new type of measuring apparatus designed by Gill (*M.N.*, lix. 61); a second measuring instrument of the same type was afterwards added; and at the time of Sir David Gill's retirement from the directorate in February 1907 he was able to announce that 1086 out of the 1512 catalogue plates had been measured. It is thus seen that the zone undertaken by the Cape Observatory is well on the road to completion.

Solar Parallax.—In these days, since the discovery of minor planets with peculiar orbits like that of Eros, it is not easy to speak of the older methods of determining the solar parallax in such a way as not to appear antiquated. Yet, in a retrospect over the gradual development of the methods, there are points of great interest.

It is just half a century since Airy summarised his views of the relative values of available methods of determining the solar parallax from observations of Venus and Mars. His summary was given by way of calling attention to approaching favourable oppositions of Mars in 1860, 1862, and 1877, and the two transits of

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Venus in 1874 and 1882. He pressed on the attention of astronomers the importance of observing Mars; in fact, he summed up strongly in favour of the Mars method, but at the same time he urged that the future astronomical public would not be satisfied unless all practical use were made of the transits of Venus.

It is easy to criticise after events, but looking back, with our present knowledge as to where success lies, we cannot fail to be struck with the statesmanship which Airy showed in looking far ahead and calmly reviewing beforehand the broad chances of success in attempts to utilise special opportunities for the settlement of astronomical problems.

Airy's summary reads as if he had been truly a seer of what was to be, but also as if he hardly had the courage to let so uncommon an occurrence as a transit of Venus pass by without making observations. His view was that Mars, approaching within 0·4 unit of the Earth in favourable opposition, would give better values of the Sun's parallax than Venus.

Galle of Breslau proposed in 1872 that instead of Mars one of the minor planets would be more suitable, on the ground that the smaller disc of such a planet would more than make up for the greater distance from the Earth. Galle favoured observations in both hemispheres; Airy seems rather to have thought of observations to be made at a single observatory.

It was Gill's fortune to have learned at Dunecht Observatory to appreciate the worth of the heliometer as an instrument of precision; he saw that to apply the heliometer to observations for solar parallax was the great opening. Through many of the years in the '70's he worked at this problem. At Mauritius, whither he went in 1874 with Lord Lindsay to observe the transit of Venus, he made his heliometer measures of the minor planet Juno. At Ascension, in 1877, he used the heliometer to observe Mars, and his discussion of the observations gave results of high importance. Still Gill was unsatisfied: the size, colour, and phase of Mars made observations and discussion not perfectly satisfactory. The dream of his life would not be accomplished till he could determine the solar parallax afresh from observations of minor planets with a large heliometer.

He contributed a broad discussion of the other available methods in a series of papers communicated to *The Observatory* in 1877. He summed up in the sense that the minor planet method promised a completely satisfactory solution of the problem. This conviction was only deepened by the results of the heliometer observations of stellar parallax to which I have already referred.

Looking forward to available opportunities, Gill found that Iris in 1888 and Victoria and Sappho in 1889 would be exceptionally favourably placed; and being assured of the co-operation of Elkin at Yale, the work was undertaken. I have already alluded to the prompt response of the Admiralty to Gill's request for a 7-inch heliometer for the execution of the project.

The employment of the diurnal method at the Cape was not

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completely satisfactory, nor was the transport of the observer and instrument to some equatorial station compatible with Gill's other duties. The only course open was to combine the southern heliometer observations with corresponding observations in the northern hemisphere. Hence the co-operation of the directors of the observatories that possessed heliometers—viz. Yale, Leipzig, Göttingen, Bamberg, and Oxford (Radcliffe)—was invited and promptly given.

Methods were devised to meet the case of the employment of heliometers in different hemispheres. To this end the comparison stars were as far as possible selected so that when the planet was situated at the greatest zenith distance at which good observations can be made (that is, when the parallax factor is the greatest attainable), the two comparison stars should be situated one above and one below the planet. In this way the determination of the parallax is made to rest upon differences of two nearly equal distances measured by means of the heliometer.

Special attention was directed to the important point of arranging matters so that the observations themselves furnish the material for the determination and elimination of the errors. The method was to be, so far as practicable, "self-correcting." Errors of scale were eliminated by selecting stars nearly equidistant from the planet; errors due to personal habit of the observer were minimised by the use of a reversing prism inserted between the eyepiece and the observer's eye, so as to bring the apparent direction of separation of the images always into the same position with reference to the vertical. The same comparison stars were used in both hemispheres, and thus errors in the adopted positions of the stars were eliminated. The cunning choice of the comparison stars along the course of the three planets is well shown in the charts given in the volumes vi. and vii. of the *Annals of the Cape Observatory*, which contain the full account of the observations.

For the meridian observations of the stars the co-operation of many different observatories was asked for, and Sir David Gill summed up the situation as follows:—

"The wide-felt scientific need of such an undertaking may be assumed to be demonstrated by the fact that almost every astronomer who was appealed to entered with heart and soul into his allotted share of the work, and probably no similar astronomical undertaking has ever before received such universal and powerful co-operation."

Twenty-two observatories co-operated. Altogether 9620 observations of 115 stars were utilised; they were discussed and combined by Dr. Auwers, who also visited the Cape and took part in the observations of Victoria. From this able and thorough discussion of the meridian observations, coupled with the heliometer triangulations, the places of the comparison stars were derived with unusual accuracy. Dr. Auwers also reduced the 760 meridian observations of the planets and derived a value of the solar parallax, viz. $8''{\cdot}806 \pm 0''{\cdot}03$, a value which agrees well with

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that derived from the heliometer observations, though it is of much smaller weight.

The resulting heliometer determinations of the solar parallax were—

From Victoria, . .	8″·8013 ± 0″·0061
„ Sappho, . .	8·7981 ± 0·0114
„ Iris, . . .	8·8120 ± 0·0090
Mean, .	8·8036 ± 0·0046

—three independent determinations which agree within the limits of their probable errors.

Geodesy.—At a meeting of the British Association in South Africa (Report B.A., 1905) Sir David Gill gave an account of yet another enormous piece of work which has been carried out under the influence of his far-seeing initiative. He records how he felt that one of the duties laid on him by the traditions of the observatory and the labours of his predecessors was to interest himself in the geodetic survey of the colony.

Lacaille had measured an arc of 1¼° northwards from Cape Town in 1752. The result showed that this southern arc indicated a figure of the Earth unsymmetrical about the equator.

Nearly a century later (1841–48) Maclear revised and extended Lacaille's arc to 4½°. His result showed that the arc measured was, within narrow limits, consistent with a figure of the Earth that exhibited no difference in the northern and southern hemispheres. Lacaille's contrary deduction was found to be mainly attributable to a large local disturbance of the direction of gravity at one of the terminal stations.

Soon after his appointment as Astronomer at the Cape, Sir David Gill laid before Sir Bartle Frere, then Governor of Cape Colony, a proposal to create a system of geodetic triangles as a basis for the future accurate survey of the colony. It was a fortunate concurrence for the colonies and for geodesy that these two men—the one with his experience of Indian administration and his knowledge of the requirements of the colony, and the other with his scientific weight and practical enthusiasm—were able to deal with this question. After many administrative difficulties had been overcome, the actual work was begun in 1883. Thus was inaugurated a survey which must be an enduring benefit to the colonies, for already troubles and litigation were beginning to arise from incompatible surveys over small areas. The survey is founded upon a complete principal triangulation laid down with scientific accuracy. This could hardly have been achieved but for the initiation of Sir David Gill and the splendid devotion of Colonel Morris, R.E. (now Sir William Morris), who was in charge of the field work, ably supported by Lieut. Laffan, R.E., and other officers.

Step by step the geodetic survey has been extended, always under the scientific direction of Sir David Gill. As astronomers we may perhaps be allowed for the moment to lose sight of the

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practical advantages accruing to the colonies, and to concentrate attention on the geodetic aspect of this great work.

The surveys of Cape Colony and Natal were completed in 1896, including a rediscussion of Maclear's triangulation (*Geodetic Survey of South Africa*, vol. i.), and a new reduction of Bailey's survey 1859–62 (vol. ii.). Rhodesia was then begun in 1897, and the triangulation was carried from near Bulawayo (lat. 22° S.) to within 75 miles of the southern end of Tanganyika (8°40′ S.).

Next, in 1902, the principal triangulation of the Transvaal and the Orange River Colony was undertaken, under the superintendence of Sir W. Morris, Gill being responsible for the initiation of the work, and acting as scientific adviser. The field work was nearly completed in 1905, and the trained parties were just about to be disbanded. Sir David Gill realised that if this occurred there would be a gap left between the Limpopo River and Bulawayo in South Rhodesia, with little likelihood of its being completed. But his energetic persistence succeeded in securing support by the intervention of Sir George Darwin, whereby the relatively small link of 120 miles in the chain was made good. Thus the triangulation is complete from the southern extremity of Africa nearly to the southern end of the German Protectorate, an arc of 25° in latitude.

It is to be hoped that the German Government will be able to continue the measurement of the arc along the eastern shore of Lake Tanganyika on German territory; all the more so because, by yet another instance of Sir David Gill's energy, the measurement of an arc of $2\frac{1}{2}°$ to the north of the German territory is now being carried out.

The delimitation of the Anglo-German boundary between British Bechuanaland and German South-West Africa along the 20th meridian gave rise to some temporary difficulties in 1896. Sir David Gill was in England at the time, and was consulted by the Colonial Office. His knowledge of local conditions was invaluable; he received instructions to proceed to Berlin, and there he was able to arrange an agreement satisfactory to both of the Governments concerned, and the direction of the work was placed in Sir David Gill's hands. Bosman's longitude arc across Bechuanaland to the 20th meridian was connected at both east and west ends with the geodetic circuit in Cape Colony.

This great system of triangulation pervading South Africa will eventually give geodetic results relating to three considerable arcs of meridian:—

First, the arc along the meridian of 19° E. longitude, with an amplitude of $12\frac{1}{2}°$.

Second, the arc along the meridian of 26° E. longitude, with an amplitude of $8\frac{1}{2}°$.

Third, the great arc along the 30th meridian, with an amplitude of 25°.

As far as the reductions are completed, it would appear that there is but slight deviation from Clarke's elements of the figure of

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the Earth on any of these meridians. But in the second and third there seems to be evidence that the astronomical amplitude exceeds the geodetic by a small fraction of a second of arc per degree.

From the north, preliminary operations have already been begun by Captain Lyons of the Egyptian Survey to connect Cairo with the southern triangulation.

Sir David Gill's dream will be realised when, by the junction of Cairo round the east shores of the Mediterranean with Greece, and so with Struve's arc, the North Cape in lat. 70° N. is connected by triangulation with the southernmost point of Africa, lat. 35° S., an arc of meridian 105° in length.

My task has been a difficult one. Wisely or unwisely, I have attempted to set before you the broad lines along which Sir David Gill's achievements lie. In doing so, I have had, perforce, to leave many points of interest and importance untouched, even at the risk of seeming to fail in doing justice to his work.

I hope I have been able, however inadequately, to make clear to you that the recognition of the Council has fallen upon work of extraordinary scope, not only in administrative activity, but also in investigations of high refinement and permanent value.

Sir David Gill,—In presenting this medal to you, let me say that we know that for yourself the successful achievement of your tasks is the highest reward. But we could not deny ourselves the satisfaction of recording our appreciation of the mark which your labours in a distant land have made in the advance of astronomy. Let me convey to you the hope that your well-earned leisure may be filled with continued study of the science which you love.